# The Effect of Bundled Housing and Accessibility Information on Residential Location Choice and Travel Behavior: an Experimental Study

Jennifer Rogers
Dr. Daniel Rodríguez, Advisor
April 2009
Master's Project

Department of City and Regional Planning
University of North Carolina at Chapel Hill

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## ABSTRACT

The ability of an individual to travel via modes of transportation other than the single occupancy vehicle is limited by the availability of these alternative transportation modes near their home. The purpose of this research is to investigate the long-term effects of information on an individual's travel behavior. We hypothesize that if individuals who are making residential location decisions are provided with bundled housing and accessibility information, they will decide to live in more accessible locations and that they will travel fewer miles by car as a result. This is an experimental research study that involved incoming graduate and transfer undergraduate students at North Carolina State University (NCSU) and the University of North Carolina at Chapel Hill (UNC). We found that the average student at NCSU traveled between 4.2 and 6.2 fewer miles per day by single occupancy vehicle when accessing the university campus as a result of being exposed to the bundled housing and accessibility information. The average student selected a residence closer to the campus and had more transit stops located within a half mile of their residence. We were unable to detect an impact to UNC students, most likely due to the restrictive parking policies on campus and already short commuting distances. Foreign students and those who were previously familiar with transit that used the bundled housing and accessibility information traveled fewer miles than those who did not.

# I. INTRODUCTION

The ability of an individual to travel via modes of transportation other than the single occupancy vehicle is limited by the availability of these alternative transportation modes near their home. If an individual selects a residence that is not within walking distance to a transit stop, traveling via public transit is most likely not an option. Given the dispersed land use patterns and inter-suburb travel behavior, efforts by transit agencies to provide quality transit service to people where they live are challenging, expensive, and inefficient. Instead of adapting transit to the existing land use, this research looks at the willingness of individuals to select residential locations closer to transit and closer to their destinations.

The purpose of this research was to investigate the long-term effects of information on an individual's travel behavior. The research focused on the impact of bundled transportation and residential information on the individual's residential location choice and the resulting travel behavior. This research hypothesized that if an individual decides to live in a location that is transit-rich or highly accessible by foot or bicycle, then the individual had a greater potential to use alternative travel modes.

## Context

The motivation for this research was an interest in reducing single occupancy vehicle travel. Motorized transport contributes to a degradation of air quality with the emission of greenhouse gases and particulate matter into the atmosphere, which leads to health issues such as asthma. The Clean Air Act Amendment of 1990 linked transportation planning and air quality issues. The act determined that if a region did not reach the air quality standards, federal funding would be withheld. Regional clean air plans were required to identify transportation emissions reduction measures (TERM) that would result

in a reduction of nitrogen oxide ($NO_x$) and volatile organic compounds (VOC) from all mobile sources. State and regional governments must therefore show efforts of reducing vehicle emissions.

This study is important to climate change research interests because of the contribution of greenhouse gases into the atmosphere and criteria pollutant emissions that result from motorized transportation activity. Approximately 28% of the greenhouse gas emissions produced in the United States is generated in the transportation sector (Energy Information Administration, 2008). Increasingly, federal, state, and local agencies are addressing carbon emissions and are looking for strategies to reduce emissions from all sectors.

There are costs to the individual for traveling via motorized modes. The American Automobile Association (AAA) estimates that the average cost per year of operating a personal vehicle is $8,121 (Your Driving Costs, 2008, p. 7). Since this cost is borne individually, there is a motivation for individuals to drive less. Public transit also has a cost to the individual, which is related to travel time, waiting time, and convenience. Barriers exist for biking and walking, but are related to weather and travel time. This research aimed to investigate the effect of bundled housing and accessibility information on influencing where people decide to live, such that the barriers to traveling via public transit and non-motorized modes of transportation are reduced.

## About this research study

Previous research has focused on the impact of accessibility information in affecting short-term travel behavior. Information is often provided to individuals regarding their travel options in the short term to help with trip planning, route planning, or mode choice selection. By contrast, this research focused on the long term decisions that impact where people live and thus their ability to use multiple travel modes. By increasing the number of available transportation modes, individuals have the option to

reduce vehicle miles traveled (VMT) by the single occupancy vehicle by choosing an alternative transportation mode, such as public transit, walking, or bicycling. In addition, the ability to walk or bike someplace means that the travel distances between origin and destination are shorter, thus reducing travel as well.

There were two main questions of this research:

1. *What is the effect of bundled residential and accessibility information on the individual's travel behavior, measured by daily vehicle miles traveled by car?*

2. *How does bundled residential and accessibility information affect an individual's decision about where to live? Does the bundled information influence individuals to select residential locations with higher accessibility?*

This research builds on the Rodríguez et al. study (2005) on the relationship between accessibility and housing information on individuals' residential location choices. The study took place in a laboratory setting in which participants used a simulation tool to select residences from a database of properties created specifically for the study. Participants receiving the treatment viewed properties accompanied with accessibility information such as distance from the property to a transit stop, transit line frequency, and the distance from the property to the campus. Participants in the control group received the same information on the properties without the accessibility information. Each participant selected the top five properties that they preferred. The results showed that participants who saw the accessibility information selected properties closer to the campus. This showed a potential for accessibility information to allow individuals intending to move to select properties close to their major destination. The study also showed that older individuals were more likely to choose less accessible locations with a greater distance from transit stops and from the major destinations. Women, households who spent a

higher proportion of their monthly income on housing, and those who were already users of the transit system selected properties closer to a transit stop. Individuals who found transit inconvenient located closer to major destinations. No difference was found for individuals based on annual income (Rodríguez, 2005, p. 59).

The 2005 study was quasi-experimental and relied on stated preferences. The present study was an experimental study that used observed residential location choices and the resulting travel behavior. The next section discusses the existing research on the role of information in short- and long-term decision making that affects travel behavior. We then explain the methodology used in the experimental study design including how the data was collected and analyzed. Finally, we explain the results of the study and discuss the meaning of the results.

## II. LITERATURE REVIEW

People make decisions everyday that impact their lives for various lengths of time. In the short term, there is the decision about how one travels. In the long term, there is the decision about where to live. The decision about how to travel to work occurs every day and impacts the individual for the length of time it takes to get to work. The residential location decision however occurs only once in a while and is a long-term decision that impacts the individual's everyday activities for the length of time that they live in that location. The discussion on the role of information will provide an indication of where the greatest impact to travel can be found since the intent of this research is to reduce the miles traveled by car by individuals.

## Travel behavior decision-making

Researchers have studied the decision making process for short-term decisions such as travel mode choice. Travel behavior has been shown to exhibit characteristics of habitual behavior (Rodríguez, 2006, p. 14). Habits are defined as a sequence of acts that have become an automatic response to certain events (Aarts, 1997, p. 2). Once there is a defined goal, the automatic response of the sequence of acts is triggered. It is important to study habitual behavior because it has been found that almost half of daily actions are considered habitual (Verplanken, 2006, p. 100).

Researchers have shown that individuals with strong habitual travel mode choices acquire and utilize fewer pieces of travel related information and details about the specific trip prior to making the decision about travel mode. Instead, they rely on heuristic or low effort strategies to decide on travel mode (Aarts, 1997). Habitual behavior causes people to call upon generalized strategies to make decisions rather than performing complex calculations to compute the costs and benefits of each alternative.

Habitual behaviors influence individuals to reduce the depth of the search for information and the elaborateness of the search strategy prior to the decision (Verplanken, 1997). Those who had strong habitual behaviors looked less extensively for information because they were using simplified decision making techniques. This shows the impact of the decision-making strategy to the information collection process. If the strategy involves complexity, then detailed information about alternatives will be sought out. If the strategy is by “rule of thumb,” then less detailed information will be collected. The search strategy impacts the consideration of alternative travel options.

The acquisition of less information before making a decision for habitual behaviors indicates that people develop expectations about the performance of the environment (Verplanken, 2006, p. 91). This serves to filter the environment, such that there is less thought and deliberation about the action. This

presents a challenge to policy makers interested in influencing a mode shift or reducing travel by car. People may not notice minor changes in the environment, such as the presence of new information, even if the information presents a better solution to their current travel habits. Therefore, it is difficult to alter a person's commuting pattern once it is established, due to a reduced level of awareness and cognitive processing associated with that action.

Studies have asked participants to report on the value of information as a way to learn about the kinds of information that impacts behavior. Brög (2002) determined that "soft" information describing the comfort, convenience, privacy, and environmental impact were valued. Studies on the willingness to pay for transit information indicate that people are only willing to bear small costs in effort, time, and money to get information (Chorus, 2006, p. 262). This is related to the habitual nature of travel, in that people process only a limited amount of information when deciding how to travel. The decision to search for more information or process the information already received is based on weighing the benefits of that information to the costs of doing more work (Chorus, 2006).

The value of information and the travel alternative itself is limited by the individual's perception of the travel alternative. When the alternative is considered very unattractive, such that no amount of information would influence the individual to truly consider changing modes, the value of the information is severely reduced. Therefore, information that lowers the perception of the habitual mode can have the effect of improving the perception of the alternative. Chorus et al. (2006, p. 268) determined that the difference in value between the habitual mode was very different from the alternative travel modes, people did not utilize travel information about the alternative travel mode. This study indicates the potential of information that lowers the perception of cars to increase the influence of information about alternative travel modes. By decreasing the gap in attractiveness between the modes, people will value less attractive modes more.

Fujii investigated the effects of information on altering the perception of driving, with the belief that people who have a driver's license are more apt to drive a car than those who do not (2007). The study involved university students who just become of driving age but did not yet have a license. By telling the students about the negative aspects of driving a car, they were able to reduce the number of students who got a driver's license within the next year and a half.

Social learning theory addresses the interaction of behavior theory and decision making models (Shaheen & Rodier, 2008, p. 12). Social learning theory recognizes that environmental attributes influence one's decisions on how to act. After observing others performing an action in the surrounding environment, an individual may reproduce those actions, which reinforces it (Shaheen & Rodier, 2008, p. 12). Social marketing programs have evolved out of this theory of social learning and aim for a gradual or dynamic adoption of new behaviors.

Individualized marketing programs are social marketing programs and have had success at influencing a mode shift towards alternative modes. Washington State's King County Metro Transit influenced a 24 percent to greater than 50 percent decrease in drive alone trips and a 20 percent to almost 50 percent increase in transit use (Cooper, 2007). Individualized marketing programs provide personalized information about alternative modes of transportation to individuals interested in receiving such information. Socialdata, a leading firm in conducting Individualized Marketing campaigns in Europe, Australia and a few places in the United States, use a dialogue-based technique which actively engages people to think about the transportation mode. Each individual decides what information they need and is provided personalized information instead of generalized information that is provided through traditional marketing campaigns.

The basic premise of these programs is that people have negative misconceptions about traveling via alternative modes due to the dominance of the car in our culture and that people lack information

about these modes. Once people are provided with accurate information that applies to them, they may be more willing to travel via the alternative mode instead of the car. Behavior change in public health and community building emphasizes dialogue. The face to face contact of a conversation secures a commitment from the individual, focuses attention and interest in the topic, and allows the person to ask questions and raise issues in a comfortable setting. The conversation allows the program representative to provide personalized information to the individual. Finally, the dialogue serves as motivation to try the alternative behavior and reassurance that they are capable of performing the necessary tasks associated with the behavior change (Cooper, 2007, p. 89).

## Residential location decision-making

The residential environment represents three distinct dimensions: the dwelling, the physical structure of the neighborhood and the social dimension of the neighborhood, in terms of the neighbors (Schwanen and Mohktarian, 2004; Brower, 1996; Talen, 2001). This is important to this study because the physical aspects of the neighborhood, such as land use intensity and land use mix have been found to be an important determinant to individuals' travel behavior (Schwanen and Mohktarian, 2004, p. 761). The probability of driving a car decreases as the land use intensity and land use mix increases.

Compact urban form, mixed use, bike lanes and sidewalks, and transit availability all have some effect on travel behavior. However, their effects are often minor and complex and sometimes contradicting. Increased densities in general have been shown to lead to shorter trips and an increase in the use of alternative travel modes such as walking, bicycling, and transit (Ewing & Cervero, 2001). Mode choice is most affected by the land use. For example, Ewing and Cervero showed in their synthesis paper that transit use increases as local densities and the amount of land use mixing increases. However, they were not able to determine whether the travel mode changes were caused by the density and land use mixing

itself or by other factors. Rodríguez et al. (2004, p. 166), on the other hand, detected a negative effect of increased residential density and transit use, thus contradicting the findings of Ewing and Cervero (2004). These results support previous suggestions by Cervero and Ewing that residential densities do not play a major role in influencing mode choice. Furthermore, Rodríguez et al. suggest that as density increases, the competition between pedestrian, bicycling, and transit are affecting the attractiveness of transit. Finally, Crane found that an increase in mixed land uses generated more trips perhaps because the cost of each trip was less (2000).

A key question in this research deals with the individuals' residential decision-making process. Prashker (2008, p. 332) summarized the four categories of characteristics that people use when making residential location decisions as characteristics of the dwelling unit itself, the characteristics of the surrounding neighborhood, accessibility to the wider region outside of the neighborhood, and the socio-economic characteristics of the individual. Individual preferences for each of these characteristics exist and the choice of residential location involves a trade-off between them (Kim et al., 2005). Since some attributes associated with the housing decision take priority over others, not all characteristics will materialize in reality.

There are several theories on how the trade-offs between housing characteristics occurs. The most prevalent theory about how individuals make decisions comes from the maximization of utility theory from microeconomics. The individual is assumed to be a rationally acting agent who selects the outcome that provides them the most utility. The individual is able to compile a complete list of the alternatives and compute the corresponding costs, outcomes, and benefits that result from this solution. Once this exhaustive list is compiled, the individual weighs the costs and benefits of each of the alternatives and selects the alternative that maximizes their utility. In this theory, information is gathered about an alternative and a decision is made based on the trade-offs that this alternative will incur. Researchers of

individual choice, travel choice, and travel demand generally agree that utility maximization theory does not provide a good representation for actual decision-making (Chorus et al, 2006, p. 131).

Herbert Simon (1957) proposed the theory of bounded rationality in response to problems that he saw with the computational demands of the maximization of utility theory. Due to finite computational resources available to individuals, perfectly rational decisions are not feasible. Due to the complexity of everyday decisions, people process environmental cues and make decisions based on "rules of thumb" rather than through a complex calculation of compiling and assessing alternatives. Individuals engage in satisficing behavior such that once an alternative has been found that meets these aspiration levels, this alternative is considered to be good enough (Chorus et al., 2006, p. 131) and it is selected.

Satisficing theory and utility theory can be applied to a discrete choice framework, in which a residence that provides the best combination of attributes is selected from a finite set of alternatives (Earnhart, 2002). The housing decision is complex, (Jarvis, 2003) involving a valuation of attributes about the dwelling, the neighborhood, the neighbors, accessibility, and the socioeconomic characteristics of the individual. Kim et al. (2005) determined that the dwelling quality is a factor in the residential decision. They also found that residents prefer housing with lower density, higher quality of school, and lower price. Schools are a factor (Jarvis, 2003) and safety has been shown to be more important than transportation or accessibility (Levine et al., 2005).

The first two characteristics described by Prashker (2009) – dwelling and physical characteristics of the neighborhood – have been shown to be influential determinants in the residential location decision (Kim et al, 2005, p. 1622; Hoang and Wakely, 2000). Although less obvious, transportation and accessibility issues have been found to impact the residential decision making process. Kim et al. (2005) determined that individuals seek shorter commute time and lower transportation costs, but that these decisions are weighed against the cost of housing (Alonzo, 1964). Schwanen and Mohktarian (2004) discuss that the

preference for transportation attributes may be satisficed due to the preference of the other attributes that contribute to the residential decision and the availability of housing in the marketplace. However, there are numerous studies that point to the importance of transport to the decision on where to live. Commuting time and distance has been found to be a significantly explanatory variable in several studies (Molin, 2003; Bhat & Guo, 2004; Rodriguez, 2005; Prashker, 2008, p. 333, p. 340). The cost of commuting has also been found to be relevant (Anas, 1995), which may be a result of distance or time from the destination. Prashker (2009, p. 340) found that the utility of a residential location decreased as distance and travel time from the workplace increased. This implies that once the information on travel distance and time is provided, individuals will select the residence that is closest to their destination, as long as the other desired housing attributes are provided.

The fourth characteristic, individual socioeconomic attributes, has been found to impact the residential location decision and to reduce the importance of the transportation and accessibility in the decision. With an increase in household income, level of education, and number of cars in the household, the importance of distance between a residence and the destination decreases (Prashker, 2008, p. 340).

Since previous research has shown that transportation attributes impact the residential location decision making process, this research sought to investigate how individuals use information about bundled housing and transportation and how their decisions impact their resulting travel behavior.

# III. METHODOLOGY

## Hypotheses

The main hypothesis was that if individuals who are making residential location decisions are provided information about residential locations that have high accessibility and a diversity of transportation

options other than the single occupancy vehicle, such as transit, walking or biking, then they will decide to live in those locations. By choosing a residential location rich in alternative modes of transportation and accessible to destinations by those modes, they will be more inclined to use these modes for their travel, thereby reducing their vehicles miles traveled (VMT).

We hypothesized that exposure to bundled accessibility and residential location information influences individuals to:

1. Select residential locations that are served by alternative modes of transportation

We hypothesized that individuals would select a residence near a transit line as a result to being exposed to bundled housing and accessibility information. Even if the individuals do not relocate to the residences depicted on the map, the individuals in the experimental group would be influenced to locate closer to the transit corridors that serve the university campuses.

2. Select residential locations that are located closer to important destinations

We hypothesized that individuals would select a residence closer to the university campus if they were provided information that visually shows the distance from the residence to the university campus.

3. Travel fewer vehicle miles by car when accessing the campus

Those living in more accessible locations would have the opportunity to use alternative modes of transportation to get to campus, thus reducing their vehicle miles traveled. We hypothesized that individuals exposed to bundled housing and accessibility information would travel fewer miles by car as a result of living closer to the campus.

Even if the individual did not move as a result of the information or does not select a more accessible residence than the control group, we hypothesized that the individual will use alternative modes of transportation more, due to increased awareness of alternative modes.

Finally, we hypothesized that there will be population sub-groups that would show a greater effect on travel behavior as a result of being exposed to the information. Rodríguez et al. (2005) found that females and those familiar with the transit system were shown to live closer to a transit stop as a result to seeing bundled accessibility and housing information. As age and income increases, we expected to see less of an impact of the accessibility information on residential location and the resulting travel behavior.

## Research design

We used an experimental research design with participants assigned to an experimental group or a control group. Participants in the experimental group received an intervention, while participants in the control group did not. Data was collected on the actual behavior of the participants.

### *Study area*

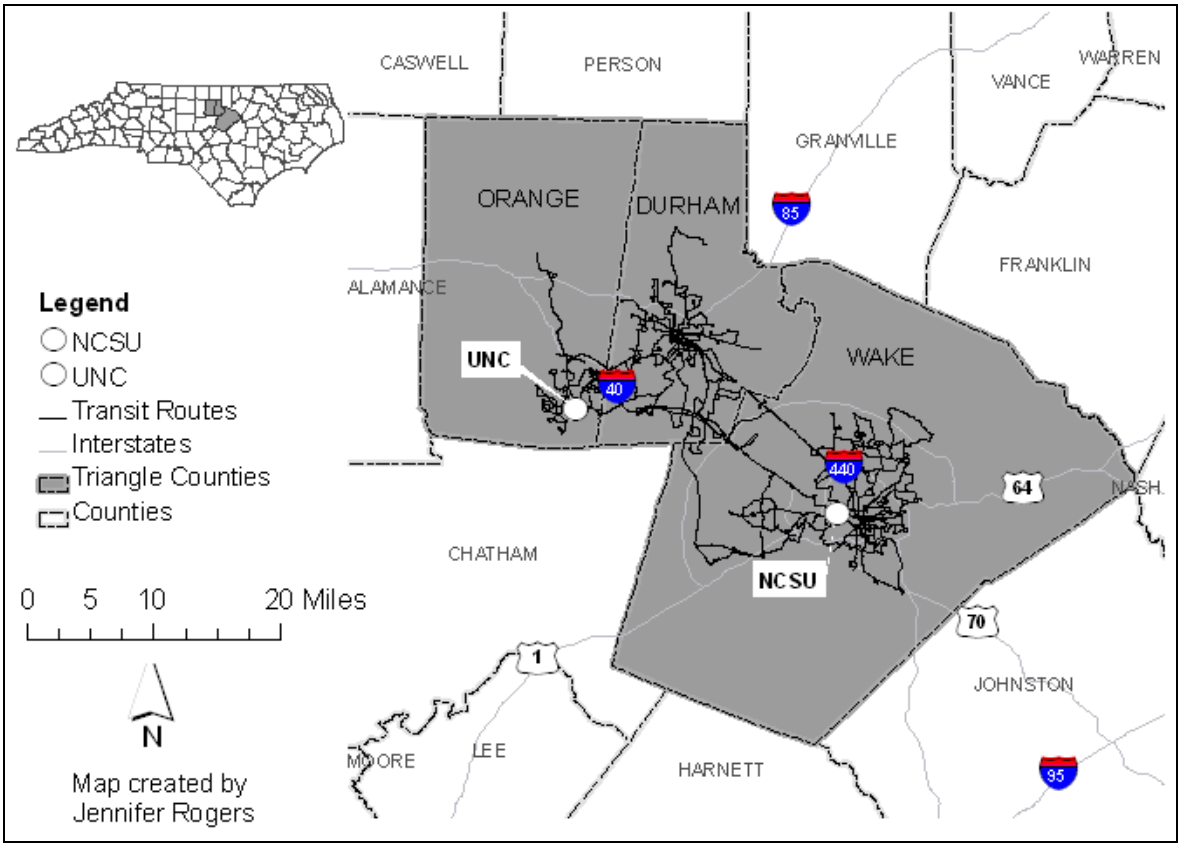
The research study involved individuals in the Raleigh-Durham-Chapel Hill metro area. The Triangle region consists of three counties: Wake County, Durham County, and Orange County. According to the U.S. Census, the population of the three counties in 2007 was 1,124,609. The mean travel time to work for Orange County residents was 21.6 minutes, 24.2 minutes for Wake County residents, and 22.7 minutes for Durham County residents and is shown in Table 1.

**Table 1: Study area characteristics**

| | Wake County | Orange County | Durham County | Triangle Region |
|---|---|---|---|---|
| Population | 770,853 | 114,277 | 239,479 | 1,124,609 |
| Mean Household Income | $80,907 | $79,150 | $64,370 | - |
| Median Household Income | $61,984 | $48,926 | $47,599 | - |
| Mean Travel Time to Work (minutes) | 24.2 | 21.6 | 22.7 | - |
| Source: U.S. Census Bureau, 2005-2007 American Community Survey Estimates. | | | | |

Triangle Transit is the regional transit authority in the Triangle and provides transit service to the three counties. Each county has its own local transit authority as well. In Wake County, Capital Area Transit provides access to downtown Raleigh and Cary Transit provides service within Cary and to Raleigh. In Chapel Hill, Chapel Hill Transit provides fare free service providing access from inside the urban service area to downtown Chapel Hill. In Durham, Durham Area Transit Authority provides transit service. A map of the study area with the transit service is shown in Figure 1.

**Figure 1: Triangle area map with transit routes**



## *Power analysis*

We conducted a power analysis to identify the sample size necessary to detect an effect of the intervention. Vehicle miles traveled (VMT) is the primary outcome variable in this study (see page 25) and was used to determine the necessary sample size. It is a continuous variable and the purpose of this study is to determine a difference between two groups.

To compute the sample size from a power analysis, representative values for the mean VMT and standard deviations of VMT were required. The 2006 UNC commuter survey reported that students travel on average 3.04 miles per week to access the university. We were interested in detecting a travel reduction of 10% for those students who received the intervention material. The standard deviation for the UNC commuter survey was one mile. For this power analysis, it was assumed that the two groups had the same standard deviation and that the same number of participants would be in each group. The default power and alpha were assumed, 0.8 and 0.05, respectively. The results of conducting the power analysis indicated that 138 students were needed in each group for those levels of power and alpha to be maintained.

## *Selection of the universities*

The research study included individuals attending two of the universities in the Triangle area. We selected university students to participate in this study because there is a large segment of that population that changes residence frequently. The possibility of a finding a group of target individuals to include in the research study was increased. Students at North Carolina State University and the University of North Carolina at Chapel Hill were included in the study.

Another necessary component to the research study was the ability to identify individuals who were in the process of looking for a new residence. In order to test the long term effects of the bundled housing

and accessibility information, it was necessary to provide the information to the individuals at the time that they are making the decision of where to live. Each fall semester, there is a group of incoming students to the universities. It was easy to identify those university students who were highly likely to be considering changing their residence. While not all incoming students were looking for a place to live, the incoming group of university students was large enough to recruit enough students to participate in the research study. Since none of these students were incoming freshmen undergraduates, the number of students living on campus was minimal.

The student populations at NCSU and UNC were large enough to recruit the number of students necessary to run a statistically significant study. The total incoming student populations for the fall 2008 semester at NCSU and UNC were well above the required number of 1,600 students per university determined in the a priority power analysis.

**Table 2: University populations for fall 2008**

| | NCSU | UNC |
|---|---|---|
| Total Incoming Students | 3,373 | 3,972 |
| New Graduate | 2,284 | 3,102 |
| Undergraduate Transfers | 1,089 | 870 |
| Total Enrollment | 32,872 | 24,876 |
| Graduate | 8,131 | 7,931 |
| Undergraduate | 24,741 | 16,945 |

Source: Fall 2008 Enrollment Statistics and Report from NCSU and UNC.
NCSU University Planning and Analysis. http://www2.acs.ncsu.edu/UPA/enrollmentdata/index.htm
UNC Enrollment Statistics. http://regweb.unc.edu/stats/census_data.php

In addition, there were several logistical aspects that made these two universities good candidates to study. At each university, there was a transportation manager who served as a key contact to the research study and provided administrative support to the project. These contacts provided a level of trust between the research staff and the university such that we were able to obtain contact information for incoming university students prior to their arrival on campus. It was necessary to contact

the students as soon as they were accepted to the University because we needed to reach them while they were deciding where they would live.

While these two universities are both located in the Triangle area of North Carolina, the built environment of the campuses is different. UNC provides free bus service from park and rides at the exterior of the town because the parking policies on campus restrict the number of parking spaces. There are 3,553 spaces on-campus available for the student population, which is 14% of the 24,000 students (University of North Carolina Public Safety). NCSU provides parking for 28% of the 32,000 students, which is approximately 9,000 parking spaces (T. Bhattacharya, personal communication, March 30, 2009). The Wolfline is a free bus service that serves the three NCSU campuses and the two park-and-ride locations. By conducting this research study in two locations in two separate cities in the Triangle, we can identify differences in decision making for individuals living in different built environments.

Finally, these two universities were selected because the intervention maps had already been created for the universities. Triangle Transit partnered with the transportation departments at these two schools to create the map that was used in the study.

### *Selection of the participants*

Participants included incoming undergraduate transfer students and graduate students of North Carolina State University (NCSU) and the University of North Carolina at Chapel Hill (UNC). These students were selected because they were likely to be looking for a new residence off campus, although we did not exclude participants if they chose to live on-campus. From the list of all incoming graduate and transfer students, 1,600 randomly selected students from NCSU and 1,600 randomly selected students from UNC. Half of these students were randomly selected to participate in the study in the

experimental group. The remaining 800 students were included in the control group. The students who responded to the initial email invitation and completed the online travel survey were considered participants in the study and were entered into a drawing to win a prize. Students who do not respond to the invitation or declined to participate were not considered participants in the study.

The university registrars for each of the schools provided the contact information for students accepted to attend the university in the fall. This information was received in April 2008, which is after the general acceptance date for both the universities. It was not known for sure whether the students would attend the university.

There were 1,957 incoming transfer and graduate students at UNC who had been accepted and had an email address specified. There were many student records that did not contain an email address, but it was necessary to have an email for each student so that the invitation email would be the same method for every potential participant. Of these students, 1,221 had paid the enrollment deposit. An additional random sample of 379 students who had been accepted but who had not yet paid their enrollment fee (730 total) were added to this list in order to get a list of 1,600 students. The purpose of including all the students who had paid the enrollment fee was to exclude the number of students who were not intending to attend UNC.

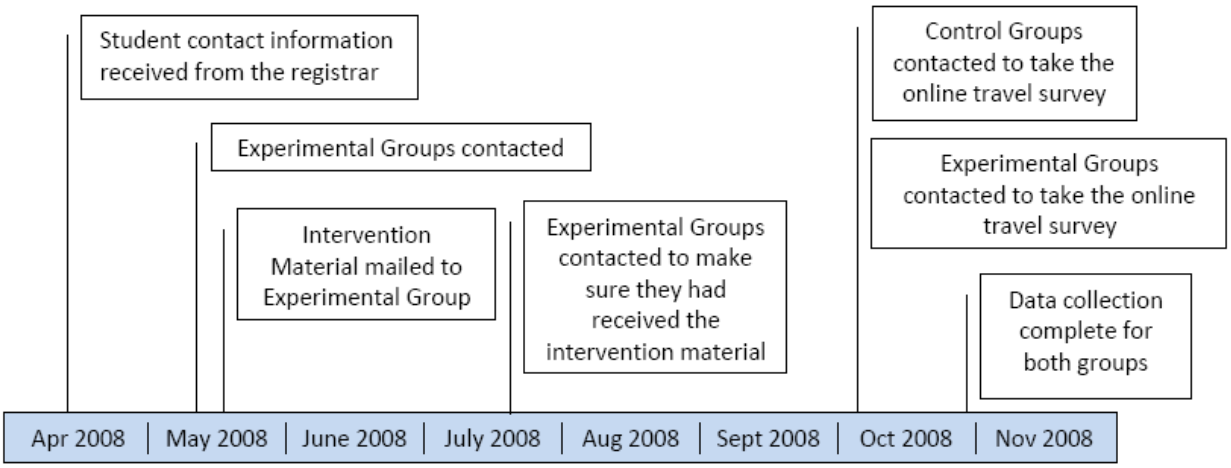
There were approximately 2,800 incoming transfer students and graduate students at NCSU at the time we collected the list of students. The SAS command “Proc SurveySelect” was used to generate a random sample of 1,600 students from this list. All NCSU students had email information on file.

### *Participant recruitment and communication*

The students invited to join the experimental group were contacted in May 2008. The students in the experimental group who responded to the invitation to join the study were mailed the intervention

material by June 2008. The online travel survey was administered to both the experimental and control groups from October through November 2008 and they received the same survey to complete. The 800 students in the control group were first contacted with the invitation email to take the online survey in October 2008. Figure 2 shows an overview of the communication with participants.

**Figure 2: Overview of communication with students**




## *Intervention description*

The intervention material for this research study was a map of the area around the universities called the "Smart Moves Apartment Finder" map. Each of the universities had a separate map (see Figure 3 – Figure 6).

The Apartment Finder map was designed by Triangle Transit in collaboration with the universities in January 2007. The purpose of the map was to show the relationship of the location of transit routes and apartment complex locations, shopping center locations, and main campus destinations. The map also shows bicycle and pedestrian facilities. The map is printed on glossy paper 27 inches wide by 18 inches tall and folds up into a pocket sized pamphlet.

One side of the brochure includes a map of the area around the campus with the campus area in a shaded color. The bus routes are drawn on the roads and are color-coded based on the agency that provides the service. Apartment complexes are indicated on the map with a triangle and the bus route numbers that serve the apartment is printed next to the name of the complex. Parks, bike lanes, and greenways are shown. UNC has a commuter alternatives program that allows commuters who live outside a 2-mile radius of the campus to get a free bus pass and park-and-ride sticker. This 2-mile radius is drawn on the UNC map.

The other side of the brochure includes a listing of the apartment complexes and the bus routes that serve them. It includes instructions on how to ride the bus, the benefits of using alternative transportation modes, instructions on the bus routes to take to get to important local destinations, and where to get additional information about alternative transportation modes.

The map was mailed through the post office to the participants in the experimental group and was available online for those participants who wanted an electronic version.

**Figure 3: Front of the Smart Moves Apartment Finder map for NCSU**

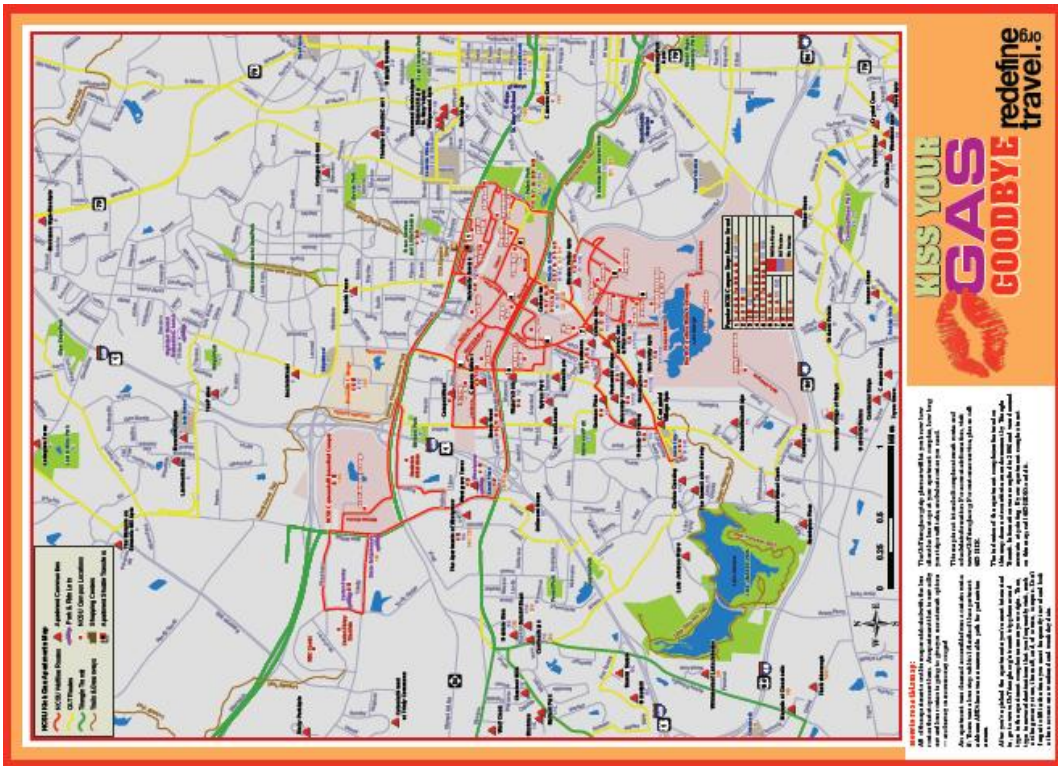



**Figure 4: Front of the Smart Moves Apartment Finder map for UNC**

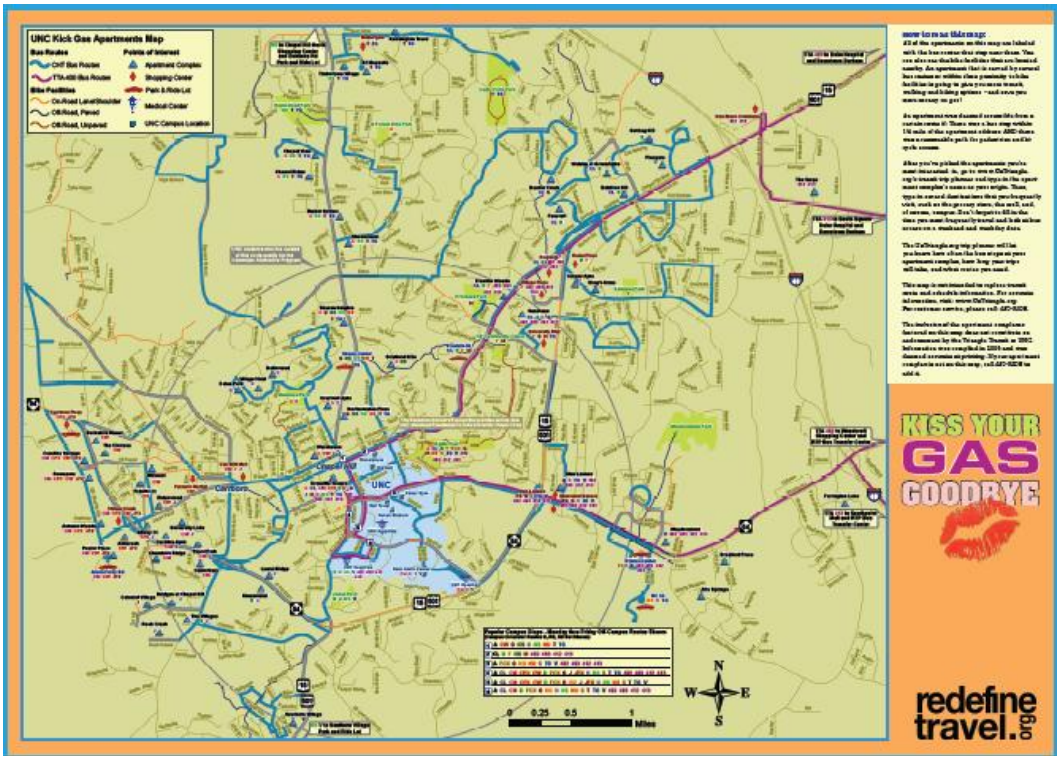


**Figure 5: Back of the Smart Moves Apartment Finder map for NCSU**

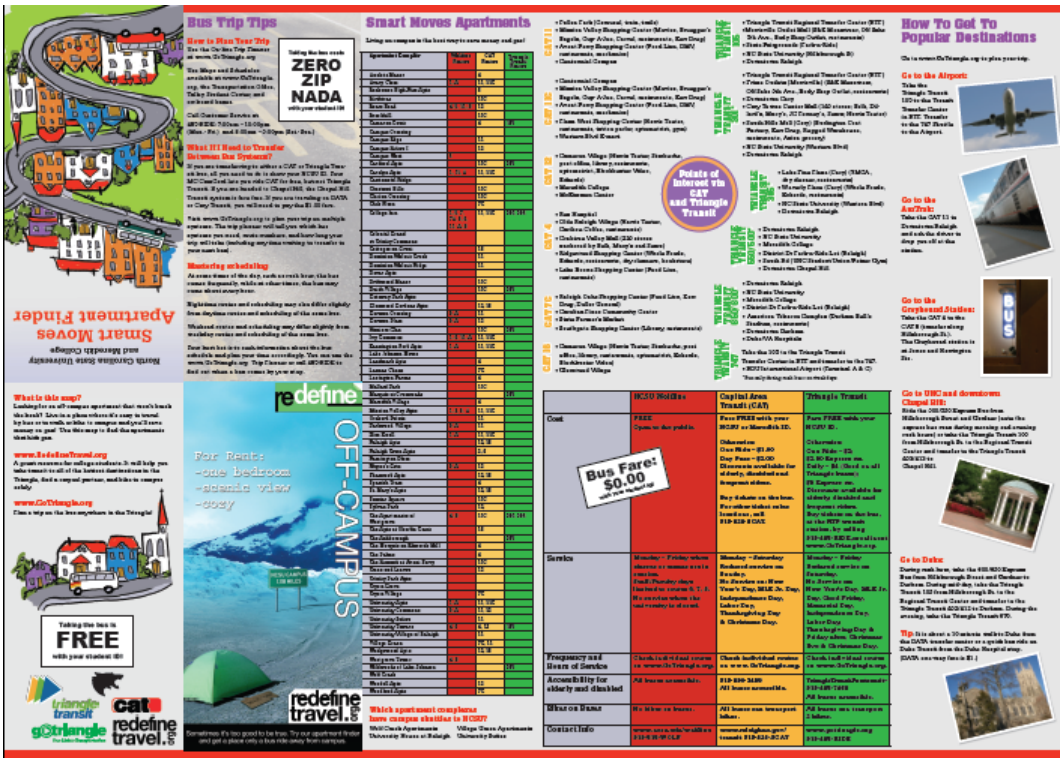



**Figure 6: Back of the Smart Moves Apartment Finder map for UNC**

### *Intervention administration*

The students who were invited to join the experimental group were contacted in May 2008 for the first time. This contact was the email invitation to join the study. They were instructed to visit a website to provide contact information for the summer and to indicate their intention to move. This website provided further instructions about the confidentiality of data collected during the study, study administrator contact information, and terms of agreement. By submitting the information on the website, they indicated that they understood that they were participating in the study. A confirmation email was sent to the email address they provided on the website that explained the details of the study further and served as a resource for later. After a week, a reminder email was sent to the experimental group students who had not joined the study that indicated they still could join.

Within a week of entering in their information on the website, the intervention material (the map) was sent through the mail to the home address they provided when joining the study. Included with the map was a welcome letter, which requested that the participant log on to another website to answer questions about the map they had just received. The intent of the questions was to ensure that the participants had received the map, looked at it, and was able to answer a few simple questions about it. A follow-up email was sent to participants who did not visit the website to answer questions on the map.

During the summer, there was minimal communication with the participants in the experimental group. A short email was sent to all participants to remind them that they were part of the study and that there would be an online travel survey in the fall once the semester began. In addition, the email provided a link to the online version of the intervention material and offered that a new map could be mailed to

their home address if they wanted a new one. This completed the communication that was specific to the experimental group. A transcript of these documents is available in the appendix.

**Table 3: Timeline of communication with participants – administration of the intervention**

| Communication Activity | NCSU | UNC |
|---|---|---|
| Invitation to join | Tuesday May 13, 2008<br>8am - 1:15pm | Wednesday, May 7, 2008<br>12pm-2pm |
| Email reminder to join | Thursday, May 22, 2008<br>11am-3pm | Friday, May 16, 2008<br>9am-1pm |
| Intervention map mailed | May 19, 2008 – June 17, 2008<br>7 mailings | May 13, 2008 – June 17, 2008<br>10 mailings |
| Email reminder to answer questions on the map | May 28, 2008 – June 11, 2008<br>3 mailings | May 20, 2008 – June 11, 2008<br>3 mailings |
| REI coupons mailed | May 28, 2008 – June 27, 2008<br>8 mailings | May 21, 2008 – June 27, 2008<br>10 mailings |
| Email contact during summer | July 30, 2008 | July 30, 2008 |

## *Cross-contamination concerns*

The Smart Moves Apartment Finder map is currently in public circulation. For UNC students, it is available at the UNC Department of Public Safety and the Orange County Visitor's Center. For NCSU students, it is available at the NCSU Transportation office. Additionally, it has been provided to students as part of an orientation packet that they receive at orientation events. During the study, the transportation coordinators in the universities were requested to not provide the map to students at orientation events in order to avoid cross-contamination. However, the map remained in circulation at the departments and other public locations.

The availability of the map was a concern as students who were part of the control group potentially had access to the map. We determined that this issue was less of a concern because of the limited availability of the map to on-campus locations and locations near the university. The map was not mailed to students homes and was located only at a few locations. Therefore, control group exposure was limited.

Finally, the issue of cross-contamination was also addressed by adding a survey question about whether the participant had used the Smart Moves Apartment Finder map when selecting a place to live. An image of the map was provided in the survey so that visual recognition of the map would increase the quality of the responses to this question. Those individuals who indicated that they had used the map were removed from the control group during data analysis.

## Outcome variables and analysis

The outcome variables analyzed and tested for in this research study are determined by the hypotheses and research questions previously described. There are two questions that this research is attempting to answer.

**Research Question:** What is the effect of bundled residential and accessibility information on the individual's travel behavior, measured by daily vehicle miles traveled by car to access the university?

**Table 4: Outcome variable for travel distance analysis**

| Outcome Variable | Units |
|---|---|
| Daily vehicle miles traveled by car (VMT) | Miles |

We use an analysis of variance model to detect a significant difference between the mean daily vehicle miles traveled by car for participants in the two groups. We use a regression model to determine if the difference between the means of the two groups for each of the universities and for all participants are statistically significant.

**Research Question:** What effect does providing bundled residential and accessibility information have on the accessibility of where an individual decides to live?

**Table 5: Outcome variables for residential location analysis**

| Outcome Variable | Units |
|---|---|
| ***Access to transit*** | |
| Average network distance to closest transit stop | Miles |
| Average bird's eye distance to closest transit stop | Miles |
| Within ¼ mile of a transit stop | Percentage |
| Within ½ mile of a transit stop | Percentage |
| Average number of bus stops within a ¼ mile of residence | # of stops |
| Average number of bus stops within a ½ mile of residence | # of stops |
| ***Pedestrian and bicycling friendliness*** | |
| Average network distance to campus | Miles |
| Average bird's eye distance to campus | Miles |
| Population density | Pop/acre |
| Connectivity or effective walking distance | Ratio |

The network distance measures the distance along roads to the nearest transit stop, while the bird's eye distance measures the straight line from the home to the stop. The intent of the bird's eye analysis is to capture the pedestrian path that is not indicated on the street layer used in the analysis, since pedestrians tend to take the straightest path to the destination when possible. The percentage of participants within a quarter mile or half mile of a transit stop is used to determine if there was a difference in the number of participants in each group who lived within walking distance to a stop. Research shows that people are willing to walk a quarter mile to half mile to get to a transit stop (Ewing, 1999; Pushkarev, 1982; O'Sullivan et al., 1996, as cited in Fairfax County Government, 2006).

The outcome variables evaluating the pedestrian and bicycling friendliness measure the distance to the campus through the network and the straight line as the crow flies. As individuals live closer to the campus, the likelihood that they can travel to campus by foot or bicycle increases. Population density and street connectivity might be associated with how much people walk (Forsyth, 2007, p. 10). The population density value used in this study is the population per square mile for the census block group in 2007. Each residential location was assigned the population density for the block group they are located in.

The connectivity outcome variable used is the "effective walking area" defined by Dill (2003) in the Twin Cities Walking Study manual. The analysis is based on the street network because the street pattern can highlight issues such as the directness of routes between locations and the number of routes available (Forsyth, 2007, p. 134). The effective walking area is the ratio of the area within a quarter mile bird's eye distance from the residence to the area within the quarter mile network distance from the residence. The closer the value is to 1, the more connected the street network is.

## Data collection

### *Online travel survey*

All study participants were asked to complete an online travel survey to collect data about their travel when accessing the university campus. The survey was conducted using the online survey software called Qualtrics, which was made available through UNC. All participants were invited via email to take the online survey and were provided a link in the body of the email which brought them to a personalized survey page. Participants were required to complete the survey within one week of starting, and could come back to complete the survey if they did not previously finish it.

There were three parts to the survey: personal information, travel information, and housing information. The personal information section collected demographic data such as age, income, and gender. The travel information section collected details on travel behavior such as travel distance and travel mode for the trips to and from the university. Other travel information was collected such as number of bikes owned, car availability, and familiarity with transit. The housing information section collected data on housing preference, current housing type, and important factors when selecting a residence.

The full text of the survey is provided in the appendix. The UNC Student Travel Study survey questions are provided, although similar questions were asked in the NCSU Student Travel Study survey.

### *Incentives offered*

A single 16 GB iPod Touch was offered to participants from NCSU and UNC as part of a random selection. The iPod was mentioned in the email invitations and in many of the other correspondences with participants as an incentive to join the study and to continue participating. The iPod Touch was awarded by random and delivered once the data collection from the online survey was completed.

The second incentive offered was a 15% off coupon for an item at REI. The coupons were donated by REI for the study. This was offered to participants in the experimental group at both universities as an incentive to answer the follow-up questions about the intervention map. Every participant who completed the follow-up questions was mailed a coupon.

A third incentive was offered to all participants during the online travel survey. In order to increase the participation rate in taking the survey, a free cup of coffee was offered to those individuals who completed the survey. Participants were instructed to print out the receipt email from the survey and bring it to a local coffee shop where they could receive their free cup of coffee. This incentive was sponsored by Triangle Transit.

## Data analysis

### *Data cleanup*

Once the data was collected from the online travel survey, it was necessary to prepare the data for analysis. The data cleanup stage involved removing respondents who were not university students.

There were several non-students and students of other universities because the initial list of students included all students who had been accepted whether they had decided to attend the university or not.

Participants who did not provide a home address or did not complete the travel survey were excluded from the study. In addition, individuals were removed from the analysis who reported unexpected travel behavior patterns. Individuals who reported implausible travel patterns were removed. We were unable to determine the travel mode for people who fit this category and thus we removed them from the analysis completely.

### *Definition of the participants in the experimental and control groups*

Based on responses to the online travel survey, the list of respondents was further pared down. The intent of the analysis was to capture the long-term effects of the intervention material. Therefore, only participants who moved after being exposed to the intervention map were included in the analysis.

The experimental group included individuals who had moved residences after receiving the intervention material and had indicated that they had viewed the Apartment Finder map by answering questions about the map during the summer or in the online travel survey.

The control group included all individuals regardless of when they had decided to move residences and indicated that they had not used the Apartment Finder map when looking for a place to live.

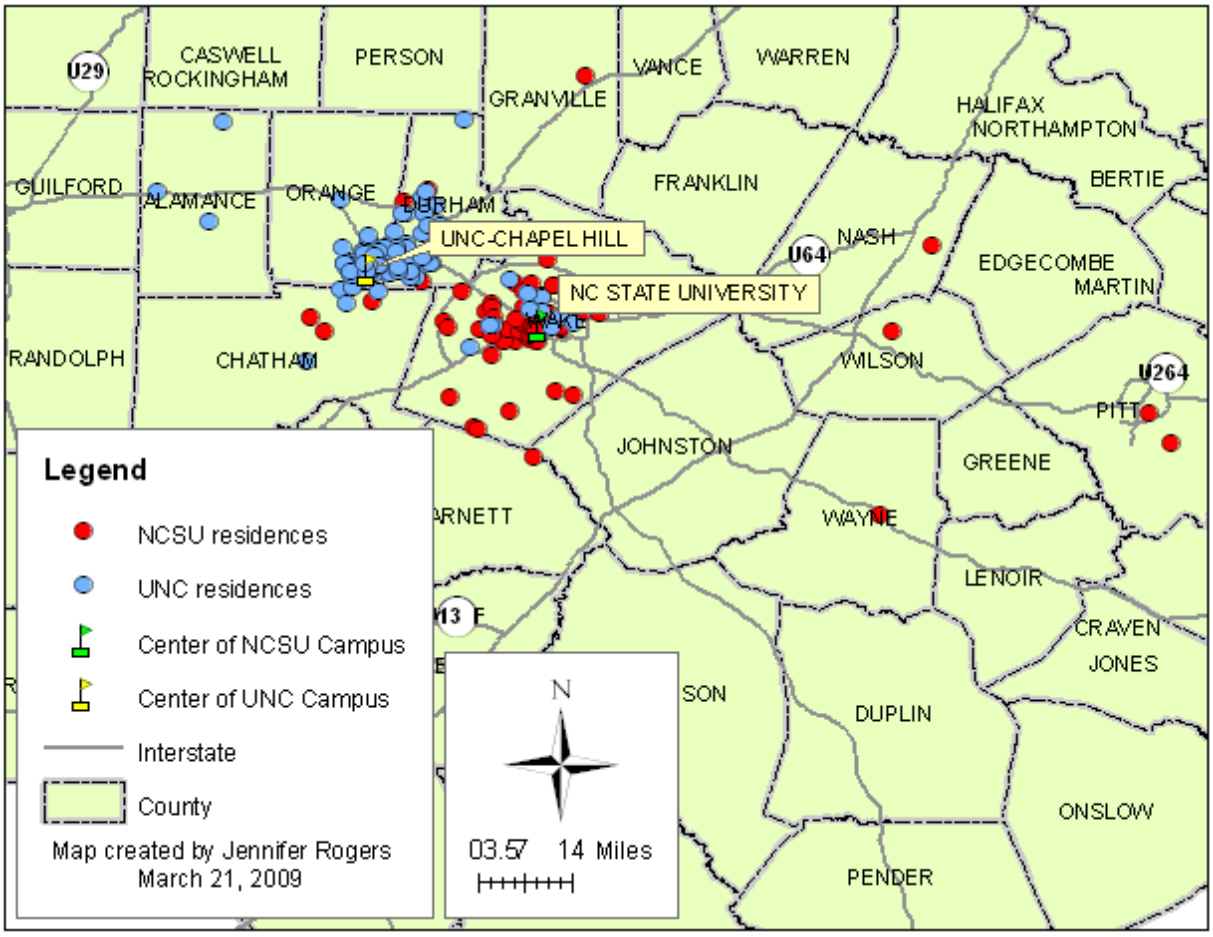
### *GIS*

ESRI ArcGIS 9.3 was used in the travel distance analysis to compute the shortest network distance from the residences to the campus. The participants provided their home address during the school year. The addresses were geocoded using ArcGIS 9.3 to the Streets 2008 layer provided by ESRI. Some data cleanup was necessary to locate residences on streets that were not included in Street 2008 layer. The

nearest street address was selected in the cases when the ArcGIS could not match the address provided by the participant.

The campus location for the universities was obtained from a GIS point layer provided by the NC Department of Administration, State Property Office from 1993-2003. The campus location was located in the center of the main campus that the participants were accessing.

**Figure 7: Selected residence locations for all participants in the study**




## *Computing the vehicle miles traveled variable*

The analysis of the vehicle miles traveled will be testing the hypothesis that when individuals are exposed to bundled residential and transportation information, they will travel fewer vehicle miles when

accessing the campus. We hypothesize that this is due to relocating in a more accessible neighborhood and/or becoming more aware of alternative transportation modes.

There are two ways that we compute the average daily vehicle miles traveled for individuals in this study: shortest distance traveled by car from home to campus and self-reported travel distance between home and campus. For both analyses, we compare the experimental group participants who relocated to a new residence after seeing the Smart Moves Apartment Finder map to the control group participants who did not see the map. The purpose of these analyses is to identify the long term effects of the intervention material on the mean daily travel distance.

### *Shortest distance analysis*

This analysis used the shortest distance from the residence to the center of campus. The individuals that indicated that they drove a car to campus in the travel survey were given a travel distance that was the shortest distance on the road network from home to campus and from campus to home. This is the daily travel of the individual accessing the campus. All other individuals were assigned a value of zero.

The analysis including individuals who indicated that they rode in a car as a passenger did not yield different results from the shortest distance analysis.

### *Self-reported distance analysis*

This analysis used the self-reported travel distance by car by participants in the online travel survey when traveling from home to campus and vice versa. An analysis of the self-reported vehicle travel distances is important because individuals do not necessarily travel the shortest path distances from their residence to campus. In this analysis, the individuals were assigned an average daily travel distance for their reported travel from home to work, which was calculated from the two days of reported travel

distances. This included all the trips in the trip chain from when the individual left the home and arrived at campus and the trips from the campus to the home.

## IV. SUMMARY OF PARTICIPATION RATES

### Experimental group

The response rate was slightly higher than expected in the power analysis. The attrition rate over the few months was 40% for UNC students and 43% for NCSU students.

**Table 6: Participation rates for participants in the experimental groups**

| | NCSU | | | UNC | |
|---|---|---|---|---|---|
| | **Number** | **Rate** | | **Number** | **Rate** |
| Invited to participate | 799 | | | 800 | |
| Joined the study | 154 | 19% response | | 149 | 19% response |
| Answered questions about the map | 84 | 55% response | | 63 | 42% response |
| Completed the travel survey | 92 | 40% attrition | | 85 | 43% attrition |

### Online travel survey

The same online travel survey was administered to participants in the experimental and control groups in October-November 2008. The following tables detail the number of participants that completed the survey and that are used in the statistical analysis. Participants of the experimental group were further excluded from the analysis if they did not move after receiving the map or indicate that they had viewed the map.

**Table 7: Total number of participants**

| Overall | | | | NCSU | | | | UNC | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Control** | **Experiment** | **Total** | | **Control** | **Experiment** | **Total** | | **Control** | **Experiment** | **Total** |
| 189 | 103 | 292 | | 85 | 45 | 130 | | 104 | 58 | 162 |

# V. RESULTS

## Travel distance analysis

The first outcome variable analyzed was the average daily travel distance by the participants when accessing the campus. We completed two analyses using the distance from the residence to the campus for individuals who reported driving a car and the actual reported distance traveled by car. The results for these two analyses are presented here, as well as the comparison between the experimental and control groups. An estimation of the daily VMT reduction is also presented.

### *Daily travel distance*

The average daily travel distance by car per person overall was 5.1 miles in the shortest distance analysis and 4.6 miles in the self-reported distance analysis. This was for all participants in the study (N=292). When looking at the results from the individual universities, the average NCSU student travels longer distances than the average UNC student. The average NCSU student traveled 6.9 miles per day in the shortest distance analysis and the self-reported distance analysis. The average UNC student traveled 3.7 miles per day in the shortest distance analysis and 2.8 miles per day in the self-reported distance.

**Table 8: Daily mean vehicle miles traveled from home to campus**

| | Overall (N=292) | | | NCSU (N=130) | | | UNC (N=162) | |
|---|---|---|---|---|---|---|---|---|
| | **Mean** | **Std. Dev.** | | **Mean** | **Std. Dev.** | | **Mean** | **Std. Dev.** |
| Shortest Distance | 5.1 | 13.7 | | 6.9 | 16.9 | | 3.7 | 10.2 |
| Self-reported Distance | 4.6 | 9.9 | | 6.9 | 11.6 | | 2.8 | 8.0 |

### *Comparing the mean daily travel distance between groups*

We used analysis of variance to detect a difference between the individuals who had used the Apartment Finder map (experimental group) and those who did not use the Apartment Finder map

(control group) for the daily mean vehicle miles traveled when accessing the university. The results show a difference for NCSU students for both of the distance analyses. We were unable to detect a difference for overall participants or UNC students.

The average NCSU student who used the Apartment Finder map traveled 2.8 miles by car per day compared to 9.0 miles for those who did not use the map in the shortest distance analysis. In the self-reported travel distance analysis, the average NCSU student who used the map traveled 4.2 miles per day by car, while the average NCSU student who did not use the map traveled 8.3 miles. The difference between the mean travel distances of these two groups was statistically significant.

**Table 9: Daily mean vehicle miles traveled from home to campus for control and experimental groups**

| | **Overall (N=292)** | | | | **NCSU (N=130)** | | | | **UNC (N=162)** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Cont. (N=189)** | **Exper. (N=103)** | **p-value** | | **Cont. (N=85)** | **Exper. (N=45)** | **p-value** | | **Cont. (N=104)** | **Exper. (N=58)** | **p-value** |
| Shortest Distance | 5.9 | 3.6 | 0.18 | | 9.0 | 2.8 | 0.05* | | 3.4 | 4.2 | 0.60 |
| Self-reported Distance | 5.3 | 3.3 | 0.11 | | 8.3 | 4.2 | 0.05* | | 2.8 | 2.7 | 0.92 |

Unit is miles
* $p < 0.1$ (90% confidence level)
** $p < 0.05$ (95% confidence level)
*** $p < 0.01$ (99% confidence level)

## *VMT reduction estimates*

The reduction in vehicle miles traveled can be computed for the NCSU students and for the overall study, which included all participants. We do not compute the VMT reductions for UNC and overall participants because we did not detect a difference in daily mean travel distance between the groups. The average NCSU student who used the map traveled 6.2 fewer miles per day in the shortest distance analysis and 4.2 fewer miles in the self-reported distance analysis. This is the equivalent to 68% reduction in VMT in the shortest distance analysis and 50% reduction in VMT in the self-reported distance analysis.

The average NCSU student who is exposed to bundled accessibility and housing information travels between 771 and 1,138 fewer miles per academic year, depending on the travel distance analysis referenced. This is computed from the daily VMT reductions for the average student. The estimation is based on the assumption that the student travels to campus five days per week for 37 weeks out of the year.

**Table 10: Average reductions in vehicle miles traveled for a student using the map**

| | NCSU | | |
|---|---|---|---|
| | **Daily VMT Reduction** | **% Daily VMT[2]** | **Annual VMT[1]** |
| Shortest Distance | 6.2 | 68% | 1,138 |
| Self-reported Distance | 4.2 | 50% | 771 |

[1]The Annual VMT analysis assumes 37 weeks in the academic year and that the student traveled to campus 5 days a week.
[2]The percent daily vehicle miles traveled is the percent reduction from the mean travel distance of students in the control group.

Khattak & Rodríguez (2005) compared the travel patterns of individuals in two different neighborhoods in Chapel Hill. They found that residents of neo-traditional neighborhoods traveled 14.7 fewer miles per day than residents of traditional neighborhoods. While the VMT reduction in this research study is less than the Khattak & Rodríguez study, this study includes only university students who selected a residence with the knowledge that they would be attending the university. It follows that the individuals involved in the study were selecting a location closer to their destination. Thus, the net VMT reduction is smaller than found in previous studies.

The social marketing programs achieved VMT reduction as well. King County's In Motion program found a 24% - 50% decrease (Cooper, 2007, p. 98) and Portland's SmartTrips program found a 13% decrease in drive alone miles (2006, p. 5). The reduction in daily VMT found in this study is greater than the reduction achieved in these social marketing programs.

Other TDM strategies incur much higher costs and do not achieve such high results. The National Association of Regional Councils conducted a study to determine the range of travel impacts of various

TDM policies (Meyer, 1999, p. 591). Employer trip reduction efforts are expected to result in up to 3.27% reduction in daily VMT, ridesharing programs can result in up to 2% reduction in daily VMT, and improvements to transit can result in up to 2.57% in daily VMT. These programs aim to change the travel behavior once the individual has selected a residence and their effectiveness is limited in comparison to the results seen in this research study.

## Residential location analysis

The second part of the data analysis includes a set of outcome variables to evaluate the accessibility of the residential locations chosen by the study participants. The three categories of outcome variables for the residential location analysis are similar to those used in the Rodríguez et al. study (2005): access to transit, destination diversity, and pedestrian and bicycling friendliness. The purpose of the categories is to investigate attributes of the built environment that measure neighborhood accessibility.

### *Mean values for the location analysis*

On average, participants in this research study selected residences more than half a mile to the nearest transit stop. The overall analysis including all participants showed a network distance of 0.69 miles to the closest transit stop and a bird's eye distance of 0.52 miles. However, over 75% of participants were located within a quarter mile of a transit stop and 89% were located within half a mile of a transit stop. This analysis includes the individuals who live outside the service area of the transit agencies in the triangle, which may be skewing the results towards distances greater than most residents really experience. Additional analyses could remove those individuals who are not within the three county Triangle area.

The street connectivity ratio was very similar for all three analyses. The ratio between the quarter mile accessible through the street network and the quarter mile buffer around the residence is 27:100 for the overall participant analysis. Students selected residences in areas with similar connectivity at both of the universities.

**Table 11: Mean values for the location analysis**

| | | Overall (N=292) | | | NCSU (N=130) | | | UNC (N=162) | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Mean** | **Std. Dev.** | | **Mean** | **Std. Dev.** | | **Mean** | **Std. Dev.** |
| ***Access to transit*** | | | | | | | | | |
| Average network distance to closest transit stop | mile | 0.69 | 4.7 | | 1.05 | 6.7 | | 0.41 | 1.95 |
| Average bird's eye distance to closest transit stop | mile | 0.52 | 3.51 | | 0.79 | 4.86 | | 0.31 | 1.79 |
| Within ¼ mile of a transit stop | % | 78% | - | | 77% | - | | 79% | - |
| Within ½ mile of a transit stop | % | 89% | - | | 88% | - | | 90% | - |
| Average number of bus stops within a ¼ mile of residence | # | 4.4 | 3.8 | | 4.7 | 4.2 | | 4.2 | 3.5 |
| Average number of bus stops within a ½ mile of residence | # | 13.5 | 9.9 | | 15.7 | 11.8 | | 11.8 | 7.8 |
| ***Pedestrian and bicycling friendliness*** | | | | | | | | | |
| Average network distance to campus | mile | 6.2 | 9.9 | | 7.5 | 12.9 | | 5.1 | 6.5 |
| Average bird's eye distance to campus | mile | 3.1 | 5.8 | | 3.4 | 7.4 | | 2.8 | 4.2 |
| Population density | pop/ sq mi | 4,104 | 2,842 | | 4,484 | 2,453 | | 3,799 | 3,093 |
| Connectivity | Ratio | 0.27 | 0.1 | | 0.26 | 0.1 | | 0.28 | 0.1 |

## *Comparing the groups*

When comparing the mean distances to a transit stops in either the network or bird's eye analysis, no difference was detected between the experimental and control groups. The results present suggestive evidence that there is a difference in the percentage of participants who live within a quarter mile of a transit stop for all individuals and NCSU students who were exposed to the map. The power of this argument could be strengthened in another study with a larger sample size. NCSU students also showed a slight difference in the percentage of students who lived within a half mile of a transit stop. These results indicate that individuals were influenced to select a residence closer to a transit stop after being exposed to bundled housing and accessibility information. Table 12 shows the results of the comparison between the groups for the location analysis.

The analysis to measure the number of transit stops near residences showed significant differences between the experimental and control groups for stops located within half a mile of the residence for all participants and for NCSU students. No difference was detected for UNC students. The average number of bus stops within a quarter mile of residences was slightly significant for all participants, although the results should be confirmed with another study with a larger sample size.

For the comparison between the experimental and control groups in the pedestrian and bicycling friendliness outcome variables, the only significant difference between groups that was detected was for the network distance to campus. The average bird's eye distance to campus was slightly significant for NCSU students. No difference was detected for population density or connectivity analyses.

**Table 12: Comparing the mean values for the experimental and control groups in the location analysis**

| | **Overall (N=292)** | | | | **NCSU (N=130)** | | | | **UNC (N=162)** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Control (N=189)** | **Exper. (N=103)** | **p-value** | | **Control (N=85)** | **Exper. (N=45)** | **p-value** | | **Control (N=104)** | **Exper. (N=58)** | **p-value** |
| ***Access to transit*** | | | | | | | | | | | |
| Average network distance to closest transit stop | 0.98 | 0.17 | 0.17 | | 1.53 | 0.15 | 0.27 | | 0.53 | 0.19 | 0.29 |
| Average bird's eye distance to closest transit stop | 0.74 | 0.12 | 0.151 | | 1.14 | 0.118 | 0.256 | | 0.41 | 0.12 | 0.33 |
| Within ¼ mile of a transit stop | 75% | 84% | 0.052* | | 72% | 87% | 0.055* | | 77% | 83% | 0.38 |
| Within ½ mile of a transit stop | 87% | 92% | 0.2 | | 85% | 96% | 0.066* | | 89% | 90% | 0.96 |
| Average number of bus stops within a 1/4 mile of residence | 4.1 | 5.0 | 0.088* | | 4.4 | 5.3 | 0.216 | | 4.0 | 4.7 | 0.234 |
| Average number of bus stops within a 1/2 mile of residence | 13.8 | 16.7 | 0.023** | | 14.4 | 19.9 | 0.015** | | 13.2 | 14.3 | 0.476 |
| ***Pedestrian and bicycling friendliness*** | | | | | | | | | | | |
| Average network distance to campus | 7.2 | 3.4 | 0.030** | | 9.4 | 2.2 | 0.001*** | | 5.5 | 4.3 | 0.239 |
| Average bird's eye distance to campus | 3.3 | 2.7 | 0.340 | | 3.4 | 1.7 | 0.056* | | 2.5 | 3.4 | 0.215 |
| Population density | 3.942 | 4,400 | 0.188 | | 4,230 | 4,965 | 0.104 | | 3,707 | 3,963 | 0.616 |
| Connectivity | 0.275 | 0.274 | 0.954 | | 0.267 | 0.258 | 0.626 | | 0.281 | 0.267 | 0.753 |

* $p < 0.1$ (90% confidence level)
** $p < 0.05$ (95% confidence level)
*** $p < 0.01$ (99% confidence level)

## Population sub-segments results

### *Demographics*

The intent of including demographic information is to learn more about the individuals in the experimental group who were more impacted by the intervention. No difference was found by gender or age for individuals in the experimental group for the shortest travel distance analysis or the self-reported travel distance analyses. The analysis using an interaction term for out of state students in the experimental group suggests that there might be an effect for out of state students. However, the significance does not show strong evidence of this effect (p-value is 0.0935).

Foreign students showed a significant difference in the travel distance after viewing the intervention material for all participants and NCSU students. The results show that foreign students who saw the bundled housing and accessibility information traveled fewer miles by car (shortest distance analysis). A difference was not detected using the self-reported travel distance analysis.

**Table 13: Output for the experimental group participants and foreign students using shortest distance analysis**

| | | Overall (N=292) | | | NCSU (N=130) | | | UNC (N=162) | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Coef.** | **p-value** | | **Coef.** | **p-value** | | **Coef.** | **p-value** |
| Experimental group | | -2.2 | 0.240 | | -6.1 | 0.113 | | 0.75 | 0.666 |
| Foreign Student | | -6.3 | 0.028 | | -10.2 | 0.028 | | -3.71 | 0.278 |
| Interaction term | | 1.8 | 0.679 | | 5.4 | 0.424 | | -0.75 | 0.914 |
| Constant | | 6.8 | 0.000 | | 10.9 | 0.000 | | 3.71 | 0.001 |

### *Familiarity with transit*

This section analyzes individuals who indicated that they had traveled by bus or train as their main mode of transportation or had used transit to get to work or school for an extended length of time. By including an interaction term which is the product of being in the experimental group and being familiar with transit, only those individuals who were in the experimental group are analyzed.

The results show that individuals who were familiar with transit and were exposed to the bundled housing and accessibility information traveled fewer miles when accessing the university campus. This analysis used the self-reported distance analysis. No significant effect was detected using the shortest distance analysis of VMT.

The average participant in the study who saw the intervention material and was familiar with transit traveled 3.2 fewer miles per day than the average participant who was unfamiliar with transit. This means that individuals who were familiar with transit were more receptive to the bundled housing and accessibility information. NCSU students familiar with transit traveled 5.8 fewer miles per day and UNC students traveled 1.5 fewer miles per day.

**Table 14: Output for the experimental group participants and transit familiarity using self-reported distances**

| | Overall (N=292) | | | NCSU (N=130) | | | UNC (N=162) | |
|---|---|---|---|---|---|---|---|---|
| | **Coef.** | **p-value** | | **Coef.** | **p-value** | | **Coef.** | **p-value** |
| Experimental group | -3.52 | 0.110 | | -4.59 | 0.244 | | -2 | 0.393 |
| Familiar with transit | -5.80 | 0.000 | | -7.34 | 0.004 | | -4.36 | 0.009 |
| Interaction term | 2.62 | 0.317 | | 1.50 | 0.746 | | 2.84 | 0.312 |
| constant | 9.18 | 0.000 | | 13.2 | 0.000 | | 5.76 | 0.000 |

**Table 15: Vehicle miles traveled for experimental group participants and transit familiarity**

| | Overall (N=292) | | NCSU (N=130) | | UNC (N=162) |
|---|---|---|---|---|---|
| Familiar with transit | 2.5 miles | | 2.7 miles | | 2.6 miles |
| Unfamiliar with transit | 5.7 miles | | 8.6 miles | | 3.8 miles |
| Total daily VMT reduction for individuals who were familiar with transit and were exposed to the information | 3.2 miles | | 5.8 miles | | 1.5 miles |

## VI. DISCUSSION

The study supports the hypothesis that when individuals are presented with bundled residential and travel information, they will travel fewer miles by car. The information presented to the individuals advertised residential locations that were located closer to the campus and closer to existing transit

lines. The analysis of the data indicates that the individuals who received the intervention lived closer to the university and traveled fewer miles by car when accessing the university.

Previous research on the interaction between land use and transportation points to the importance of residential location on travel distance and travel mode. The present study supports those findings by stating that the provision of information impacts one's residential decision making and subsequent travel behavior. The results show that individuals used the bundled accessibility and housing information to locate closer to their destination. Subsequently, they traveled fewer miles by car.

The study presented information to individuals at a time when they were likely to be searching for the information. Previous research has shown that since travel behavior is habitual, in order to invoke a travel mode shift among individuals, information about travel behavior must be presented at a time when there is a disruption in travel habits. The results of this study indicate that these individuals who were searching for a new residence utilized the bundled housing and accessibility information since they selected residences that were more accessible to the campus via alternative transportation modes. The timing of the information provision was significant.

The policy of providing information to impact where someone decides to live is cost effective compared to other transportation demand management policies. The cost effectiveness of this study was between $10 and $15 per vehicle mile traveled reduced[1]. In comparison, the TravelSmart initiative in Portland

[1] The cost of providing maps to 177 students in this research study was approximately $11,000, which is a cost of approximately $60 per person. The distribution of the map was limited and thus as the map is distributed to more students, the cost per person will go down. The study found a result 4.2 to 6.2 vehicle mile reduction per person, which is a cost of between $10 and $15 per vehicle mile traveled reduced.

cost approximately $22 per vehicle mile traveled reduced[2]. The Portland program involved community based social marketing techniques, which intend to help people overcome barriers to changing travel mode. The program involved all residents in the city regardless of whether they would be changing residence or not. Although the program achieves high rates of VMT reductions, the program cost is high. This research study shows the cost effectiveness of providing information at a transition time in the individual's life when they are looking for a new residence.

The reliability in the results is strengthened because there are two analyses of travel distance: the shortest distance and the self-reported distance. Self-reported data is often unreliable because respondents report behavior inaccurately because they forget details or are unaware of the details. The shortest network distance to the campus from the home eliminated the unreliability from the analysis and further supports the hypothesis of the study.

The research was the strengthened by the effort to attract not only people who were interested in joining a study on travel behavior, but those who were interested in winning a prize. This ensured participation from a individuals with varying interests. The high quality of the prize was intended to motivate individuals to participate throughout the length of the study.

### *Differences in Effect by Geographic Location*

The results indicate that different impacts will be expressed in different geographic locations. The average NCSU student who viewed the map traveled 4.2 to 6.2 fewer miles per day, while a difference in travel behavior was not detected for UNC students. The NCSU shortest distance analysis had low power

[2] The cost of the TravelSmart program in Portland called SmartTrips Northeast Hub was $216,800. The program involved 8,400 households and averaged a 1.19 VMT reduction per person. This resulted in a cost of $21.49 per vehicle mile reduced.

(power = 0.77). Low power would cause an effect not to be detected when there really was one. Since we were able to detect a significant difference, it further supports the conclusion that the impact of the intervention is real. The power for the overall participants analysis for shortest distance was very low (power = 0.27). Since we were unable to detect a difference between the groups, a further study could be conducted with a larger sample size to further investigate if there really was a difference between the groups.

There are several differences between the built environments at the two universities. The availability of parking has been shown to have a major impact on the travel mode choice of individuals. UNC provides enough parking permits for 14% of the student body while NCSU provides enough for 28%. Since there is a higher availability of parking on the NCSU campus, individuals have an easier time traveling by car to access the campus and the need to travel via alternative modes is reduced. Previous research has shown that accessibility is an important attribute to the residential location choice. In the case of the NCSU students, this research shows that when bundled accessibility and housing information is provided, the average student locates in areas where they can travel via more environmentally friendly modes. It follows that there is a barrier that prevents the average student who is not exposed to the accessibility and housing information from locating in more accessible locations. This may have to do with the provision of information about accessibility and housing. The information was easy for the individuals in the experimental group to acquire compared to those in the control group. The average NCSU student had less of a need to search for information regarding alternative transportation modes and the information made that task much easier for individuals in the experimental group.

Since parking is more restricted on the UNC campus, rental advertisements in Chapel Hill often mention the availability of alternative transportation modes near the residence. This may have had an impact on

the effectiveness of the bundled accessibility and housing information in Chapel Hill. It may be that such information is more effective in areas where alternative transportation is less of a dominant issue.

The surrounding land use around the universities is different, which could have an impact on the commuting behavior of the university students. Raleigh covers a metropolitan area almost six times that of Chapel Hill (140 square miles compared to 21 square miles). Both towns provide significant land area for residential use (over 42% in Raleigh compared to 53% in Chapel Hill), but given the size of the metro areas, there are more housing opportunities available at further distances from the University campus in Raleigh than in Chapel Hill. The largest percentage of residential land use in Raleigh is in the northeast, north, and northwest planning districts (City of Raleigh Planning Department, 2008, p. 56). As a result, NCSU students commute longer distances to campus on average than UNC students. This research study found that NCSU students commute 6.9 miles per day compared to 2.8 to 3.7 miles per day for UNC students. The longer commuting distance for NCSU students indicates that individuals are more sensitive to ways that they can reduce their commuting distance.

## VII. LIMITATIONS OF THE STUDY

While there are many statistically significant results, there may be some limitations to the study. Unobservable differences between the experimental and control groups may have been the cause of the results. Due to the design of the study, participants in the control group and experimental group were invited to join the study at different times of the year and the length of participation in the study varied. In addition, the text of the initial invitation emails varied slightly between the groups due to the task that each group was required to participate in.

There are several ways that the results of the study could have been improved. The greatest impact on decision making would be achieved if the intervention were presented to the individual at the exact

moment that they are making the decision about where to live. In this study, the experimental group participants received the intervention map at a time related to the study instead of related to when they were making a decision about where to live. Secondly, it is difficult to measure the depth at which the participants studied the intervention map since it was mailed to their home address. Finally, the information presented in the map was limited. Contact information, pricing of the residential units, and transit schedules are examples of information that was lacking from the map but plays a role in the decision making process for picking a place to live.

This research relied on actual residential location decisions and travel behavior. The benefit of studying actual behavior is that it is more accurate than studying stated preference responses. Survey research shows that stated preference studies are not good predictors of actual behavior (Rodríguez et al., 2006, p. 70). However, due to irregularities in the market, such as a limited number of housing options, actual preferences for residential location may not show up in studies of actual residential location decisions (Yago, 1983). In fact, studies have identified dissonance between people's housing preferences and their actual housing location (Levine et al., 2005; Schwanen and Mohktarian, 2004, 2005; Feldman, 1990).

# VIII. CONCLUSIONS AND IMPLICATIONS

## Conclusions

The purpose of this research is to investigate how individuals use bundled accessibility and housing information to decide on a residential location and how that decision impacts their subsequent travel behavior. State Department of Transportation's and regional and local governments are interested in reducing vehicle miles traveled by car in order to comply with federal requirements and to reduce the demand for travel via the private car due to environmental concerns. We used an experimental research

study design to investigate the residential location decision and travel behavior of university students at NCSU and UNC.

We found support for the hypothesis that if individuals are presented with bundled accessibility and housing information, they will travel fewer miles by the single occupancy vehicle. We found that the average NCSU student traveled between 4.2 and 6.2 fewer miles by car per day when accessing the campus. This is a reduction in VMT of 50 percent to 68 percent from the average student who was not exposed to the intervention. We were unable to detect a difference for all the participants or for UNC students. Given the differences in the built environment on the NCSU and UNC campuses and in the surrounding urban areas, it is likely that when the average commuting distance is high, individuals are more sensitive to opportunities to reduce their commute.

Other reasons that the information had an impact on students at NCSU and not in the other locations are likely due to the differences in the parking policies at the universities and the availability of housing in the metropolitan area in the cities where the universities are located. NCSU provides more parking on-campus, which reduces the need for individuals to locate close to the campus and the City of Raleigh offers a much larger metropolitan area in which to find housing. The search for information about alternative transportation modes is expensive and unless the search is necessary, individuals will select a residence without such information. We find that providing the information in an integrated manner eliminates the costly search since individuals at NCSU used the information provided in the intervention map by selecting more accessible residential locations.

We found support for the hypothesis that if individuals are presented with bundled accessibility and housing information, they will select more accessible residential locations. We found that individuals exposed to housing and accessibility information located in areas with a greater number of transit stops within a 1/2 mile radius. Similarly, we detected a slight indication that a higher percentage of individuals

in the experimental group select a residence within a 1/2 mile of a transit stop than in the control group for students attending NCSU. We detected that individuals who were exposed to bundled housing and accessibility information located closer to the campus when distance is measured over the road network. We detected a slight difference in the bird's eye distance to the campus for NCSU students who viewed the map.

The results of the study did not show a difference in response to the bundled accessibility and housing information based on age or gender. A slight difference was detected for out of state students. The greatest impact was found for foreign students and for those students who were familiar with transit before attending the university. Targeting these individuals will have the greatest impact on reducing vehicle miles traveled to the campus.

## Implications

The results are impressive for researchers and policy makers who are looking for ways to reduce vehicle miles traveled. The reduction in daily miles traveled by car for the average NCSU student was between 4.2 and 6.2 miles depending on the analysis (self-reported distance and shortest distance). This equates to a reduction in approximately 771 to 1,138 miles traveled by car per academic year for the average person. The simplicity of the intervention, which involved mailing a map to individuals who were expected to be looking for a new residence, indicates the effectiveness in reducing daily travel of this low cost effort to provide information.

## Suggestions for future research

While this study focused on university students, the research could be expanded to other segments of the population. The university was an attractive target population due to the rigid start date of the fall

semester. However, similar studies could be conducted at large employers who have new employees relocating to the area. Targeted intervention material could be developed for these populations to see the impact on the residential location decision and subsequent travel behavior.

The research could be expanded to provide the intervention differently. A study that more closely provides bundled transportation and residential information to the individual at the exact time that they are looking for a place to live would more accurately test the effect of this information. It would be interesting to see the effect of providing the information in the format that people are looking for residential information, such as in an online search or in the newspaper.

The bundled accessibility and housing information in this study was presented in a map format only. Further research could investigate the impact of providing accessibility information in a numerical format, such as distance to campus from each residence. Another method of providing accessibility information about a residence is with a rating system similar to that provided in the Rodríguez et al. study (2005).

Further studies could incorporate information about the quality of the transit at each residence. High quality transit has been shown to be important for individuals selecting residences (Rodríguez et al., 2005). The information provided in this research study did not indicate the quality of the transit provided at each residence and this aspect of the residential location decision could not be investigated.

# APPENDIX I. TRANSCRIPT OF INTERVENTION ADMINISTRATION

## a. Invitation to join the study

**From:** Triangle Transit UNC Student Travel Study
**Subject:** Take part in UNC student travel study

Dear Student,

You have been randomly selected to participate in a study that will help local decision-makers better understand the transportation needs of Triangle area students. By participating, you will be entered into a drawing for a 16GB iPod Touch once the study is complete. To participate in the study go to http://www.redefinetravel.org/unc-study.

As part of the study, we will first ask you to confirm your mailing address and preferred email address. In return, you will receive some useful information in the mail that will help familiarize you with housing options around UNC. Once the fall semester begins, we will email you a brief online survey to collect information about how and when you travel from one place to another. Your participation in this study is voluntary and confidential.

To participate in the study go to http://www.redefinetravel.org/unc-study.

If you have any questions about the study, please contact Jennifer Rogers at jrogers@triangletransit.org or 919-485-7529.

Thanking you in advance for your time,

Jennifer Rogers

Project Director for the Triangle Transit Student Travel Study
Email: jrogers@triangletransit.org
Telephone: 919-485-7529
www.triangletransit.org
www.redefinetravel.org

This study is sponsored by Triangle Transit, the regional transit authority in the Research Triangle area in North Carolina, and RedefineTravel.org, a student resource for information about alternative modes of transportation.

## b. Email reminder to experimental group to join the study

**From:** Triangle Transit
**Subject:** UNC student travel study

Dear %%firstname%%,

Last week, you received an email invitation to participate in a study about travel patterns of Triangle area students, but we have not yet received a response from you. Your participation in the study will help local officials learn more about student travel needs and enter you into a drawing to win a **16GB iPod Touch**! To participate in the study go to http://www.redefinetravel.org/unc-study.

As part of the study, we will first ask you to confirm your mailing address and email address. In return, you will get some useful information in the mail that will help familiarize you with housing options in the area around UNC. Once the fall semester begins, we will email you a brief online survey to collect information about how and when you travel from one place to another. Just to let you know, your participation in this study is voluntary and confidential. But, we hope you will take part!

To participate in the study go to http://www.redefinetravel.org/unc-study.

If you have any questions about the study, please contact Jennifer Rogers at jrogers@triangletransit.org or 919-485-7529.

Thanks for your time!
Jennifer Rogers
Project Director for the Triangle Transit Student Travel Study
Email: jrogers@triangletransit.org
Telephone: 919-485-7529
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www.redefinetravel.org

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## c. Website to join the study

redefine travel.org

triangletransit

student travel study

### Triangle Transit NCSU Student Travel Study

Thank you for deciding to participate in the study! Your involvement will help researchers and local decision-makers understand the travel needs of students in the Triangle area. Please fill out the form below to enter the study.

As a sign of our gratitude for your time, you will be entered into a raffle to win a **16GB iPod Touch** once you complete the online survey in the fall of 2008!

**Name** *
First Last

**Preferred Email** *

**Current Mailing Address** *
Street Address
Address line 2
City
State / Province / Region
Postal / ZipCode
United States
Country

**Are you planning to move before the fall semester?** *
- Yes
- No
- I'm not sure yet

**If so, do you already have a place to live?**
- Yes
- No
- I'm not moving

**Information about the study**
Participation in the study is voluntary and confidential. The study will begin once you submit your information and will conclude when you complete the online survey during the fall semester in 2008. You will receive information at your current mailing address that will familiarize you with the Raleigh area as well as provide information about apartments located near the University. In the fall, we will contact you via email with a link to the online survey.

**Why should you participate?**
You will be entered into a drawing to win a **16GB iPod Touch** once you complete the online survey in the fall!

**Questions?**
If you have questions about the study, please contact the project director, Jennifer Rogers, at jrogers@triangletransit.org or by phone at 919-485-7529.

This study is sponsored by Triangle Transit, the regional transit authority in the Research Triangle area in North Carolina, and RedefineTravel.org, a student resource for information about alternative modes of transportation.
www.triangletransit.org
www.redefinetravel.org

**Agreement to participate**
I have read and understand the above information. By providing information and submitting this form, I agree to participate in this study with the understanding that I may withdraw at any time.

Submit

## d. Letter included with intervention material


May 19, 2008
Dear Yifeng,

Thank you for agreeing to participate in the Triangle Transit Student Travel Study! You are helping local researchers and decision-makers better understand the transportation needs of Triangle area students. Included with this letter is a map of Raleigh called the "Apartment Finder" to help give students like you information about apartments close to campus so that you can easily get to your classes. We hope that this information will be useful to you as you prepare for the upcoming school year. Take a look!

For your first activity in this study, go to **www.redefinetravel.org/ncsu-question** to answer a question about the map you have just received. As a bonus, by answering the question on the website, you will receive a **15% off coupon to REI**!

We have also provided the map online at www.redefinetravel.org/apartments for your convenience. Select the "Map" under the NC State header for the map of Raleigh. In return for your participation in the study, *today and through the fall with the brief online survey*, you will be entered into a drawing to win a 16GB iPod Touch!

If you have any questions about the map or study, feel free to contact Jennifer Rogers, at jrogers@triangletransit.org or by phone at 919-485-7529.

We'll email you once the fall semester begins so that you can take the final online survey. Thanks for being part of this study!

[redacted]

Jennifer Rogers
Project Director for the Triangle Transit Student Travel Study
Email: jrogers@triangletransit.org
Telephone: 919-485-7529
www.triangletransit.org
www.redefinetravel.org

redefine travel.org REI www.rei.com This study is sponsored by Triangle Transit, the regional transit authority in the Research Triangle area in North Carolina, and RedefineTravel.org, a student resource for information about alternative modes of transportation. Coupons provided by REI.

## e. Email reminder to visit website to answer questions about the map

**From:** Triangle Transit
**Subject:** NCSU student travel study first activity

Dear %%firstname%%,

Last week, we mailed you the "Smart Moves Apartment Finder" map to your mailing address. As your first activity for the Triangle Transit Student Travel Study, we ask that you answer a few questions about the map online. If you haven't yet answered the questions, you still can! The web address is www.redefinetravel.org/ncsu-question and by completing the quick question survey, you'll receive a **15% coupon to REI**! Additionally, you'll still be eligible for the drawing for a 16GB iPod Touch once the study is completed in the fall of 2008.

If you haven't received your map, you can email the project director, Jennifer Rogers, at jrogers@triangletransit.org. We'll put a map in the mail for you right away. You can also view the map online at www.redefinetravel.org/apartments. Then, select the "Map" under the NCSU header for the map of Raleigh.

Thanks for your participation in the Triangle Transit NCSU Student Travel Study! We'll contact you again through email during the summer to see if you have any questions about the study and then in the fall with the web link to the online survey.

Have a great summer!

Jennifer Rogers
Project Director for the Triangle Transit Student Travel Study
Email: jrogers@triangletransit.org
Telephone: 919-485-7529
www.triangletransit.org
www.redefinetravel.org

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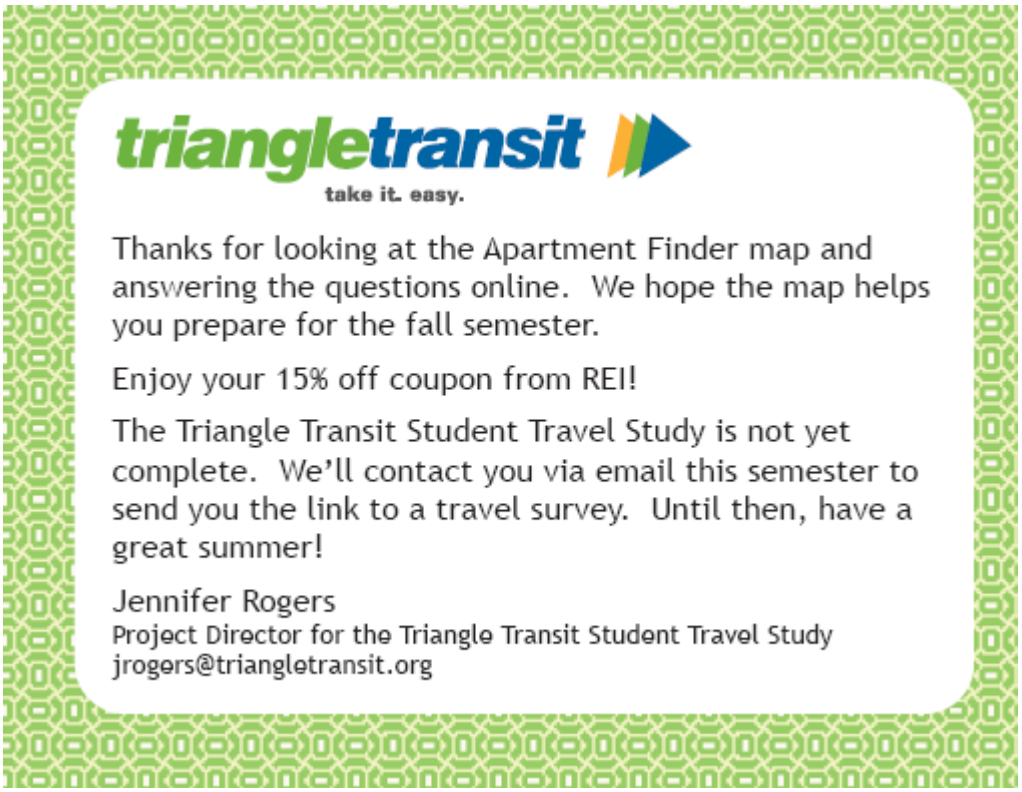
## f. Letter included with REI Coupon



## g. Email contact during summer

**Subject:** Student Travel study – map
**From:** Triangle Transit

Dear <Student>,

Thank you for agreeing to participate in the study about student travel behavior. Earlier in the summer, we mailed you an "Apartment Finder" Map of the Raleigh area, which is meant to give students like you information about apartments close to campus so that you can easily get to your classes. As the beginning of the fall semester gets closer and you find yourself still searching around for a place to live, take a look at the Apartment Finder map for ideas.

If you have misplaced the printed version of the map and would like to receive another, send an email to Jennifer Rogers, at jrogers@triangletransit.org with the subject line "Send new map". Be sure to include the mailing address where you would like to receive the map. If you'd like, you can also get the map online at http://www.redefinetravel.org/apartments. Click on "Map" under "NCSU & Meredith".

We will email you once the fall semester begins to send you a link to the online survey. By completing the online survey, you will be placed in the drawing for the iPod Touch.

Thanks again for participating in the study. Good luck in the start of the fall semester!

Jennifer Rogers
Project Director for the Triangle Transit Student Travel Study
Email: jrogers@triangletransit.org
Telephone: 919-485-7529
www.triangletransit.org
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# APPENDIX II. INVITATION TO TAKE THE ONLINE TRAVEL SURVEY

## a. Email invite sent to experimental group participants

**From:** Triangle Transit
**Subject:** UNC travel study – final step!

Dear ${m://FirstName},

Thanks for signing up earlier in the summer to participate in the Triangle Transit UNC Student Travel Study. As part of the study, we sent you a map in the mail to your home address.

Now, for the final step in the study, please complete the online survey about how you travel to campus. It should only take about 5 minutes to complete the survey and you will be entered into a drawing for an **iPod Touch** when you finish!

Your continued participation in the study is very important to the success of the study. To complete the survey and for the chance to win an iPod Touch, go to: ${l://SurveyLink}.

In the survey, you will be asked about how you traveled to and from campus in the last 2 days.

If you have any questions about the study, please contact Jennifer Rogers at jrogers@triangletransit.org or 919-485-7529.

Thanks for participating in the study and helping local decision-makers better understand student travel needs.

Jennifer Rogers
Project Director for the Triangle Transit Student Travel Study
Email: jrogers@triangletransit.org
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## b. Email invite sent to control group participants

**From:** Triangle Transit
**Subject:** NCSU travel study – online survey

Dear ${m://FirstName},

You have been randomly selected to participate in a study that will help local decision-makers better understand the transportation needs of Triangle area students. By completing this 5 minute survey, you will be entered into a drawing for a **16GB iPod Touch**.

To take the survey and for the chance to win an iPod Touch, go to: ${l://SurveyLink}.

In the survey, you will be asked about how you traveled to and from campus in the last 2 days. *Your participation in this study is voluntary and confidential.*

If you have any questions about the study, please contact Jennifer Rogers at jrogers@triangletransit.org or 919-485-7529.

Thanking you in advance for your time,

Jennifer Rogers
Project Director for the Triangle Transit Student Travel Study
Email: jrogers@triangletransit.org
Telephone: 919-485-7529
www.triangletransit.org
www.redefinetravel.org

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# APPENDIX III. SURVEY QUESTIONS

## a. Survey text of UNC Student Travel Study

Welcome to the UNC Student Travel Study!
By taking this survey, you are helping local decision-makers better understand student travel needs.

The survey should take about 5 minutes to complete. Once you complete the survey, you will be entered into a drawing to win an **iPod Touch**!

Thanks for your time!

Jennifer Rogers
Project Director for the Triangle Transit Student Travel Study
Email: jrogers@triangletransit.org
Telephone: 919-485-7529
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About You

**Please enter the address where you live *during the semester*.** This may not be your permanent address, but where you stay while you are attending the university.

Your information will be kept confidential. However, you may enter the closest intersection to your home if you prefer.

* indicates required fields
Apartment/Neighborhood Name (optional)

Street Address *
City *
Zip Code *

Are you currently enrolled as a student at UNC?

- Yes
- No

Gender

- Female
- Male

Age

- < 18 years old
- 18-21 years
- 21-25 years
- 25-29 years
- > 30 years old

Race/Ethnicity

- Caucasian/White
- African American/Black
- Asian
- Hispanic/Latino
- Other:
- Decline to answer

Select the category that best describes your household income, before taxes, in the past 12 months. Do not include incomes from unrelated roommates.

- $0 - $20,000
- $20,001 - $50,000
- $50,001+
- Decline to answer

Do you have a valid driver's license? * required field

- Yes
- No

How often do you have access to a car, motorcycle, or other motorized vehicle that you can use to drive yourself around Chapel Hill or the Triangle? * required field

- Always
- Sometimes
- Never

How many adult-sized bicycles in working order do you own? * required field

- 0
- 1
- 2 or more

# Travel Information

In the next section, you will be asked about how you travel to campus and home from campus. This is the most important part of the survey, so please be as accurate as possible.

**Describe your travel to campus *yesterday*.** If you did not come to campus yesterday, use the last day you did come to campus.

For each part of your journey to campus, include:
mode of transportation
the time it took or the distance traveled (not including waiting times)

A part of your journey to campus begins/ends whenever you have stopped *for a specific purpose*.

An example would be:
For the 1st part of your journey to campus, you would select "Car as driver" and then "5 miles" for the drive from home to the Park and Ride. Then for the bus ride to campus, you would select "Local Bus" and "15 minutes" as the 2nd part of your journey. After getting to campus if you walked to get coffee, you would select "Walk" and "5 minutes" for the 3rd part of your journey. Finally, you would select "Walk" and "10 minutes" for the 4th part of your journey to campus.

Be sure to include the following events in your journey:
- Change in travel mode (car-bus or bike-bus-bike or walk-bus-walk)
- Stops along the way, such as picking up coffee or dropping off a friend
- Driving to a Park and Ride

* indicates Required - at least one mode of transportation to campus must be specified

1st part of your journey to campus yesterday

Mode of Transportation *

Duration *

2nd part of your journey to campus yesterday
Mode of Transportation
Duration
3rd part of your journey to campus yesterday
Mode of Transportation
Duration

4th part of your journey to campus yesterday
Mode of Transportation
Duration

5th part of your journey to campus yesterday
Mode of Transportation
Duration

**Describe your travel home <u>from</u> campus *yesterday*.** If you did not come to campus yesterday, use the last day you did come to campus (i.e. the same day as the last question).

For each part of your journey to campus, include:
mode of transportation
the time it took or the distance traveled (not including waiting times)

A part of your journey to campus begins/ends whenever you have stopped *for a specific purpose*.

An example would be:
You walk to the bus stop to leave campus, so you select "Walk" for "15 minutes". Then, since you took the bus for the 2nd part of your journey home, you select "Local Bus" and "15 minutes". You get to the park and ride and used the "Car as driver" for the "3 miles" to drive to the grocery store. Finally, the 4th part of your journey home was by "Car as driver" for the remaining "2 miles" home.

Be sure to include the following events in your journey:
- Change in travel mode (car-bus or bike-bus-bike or walk-bus-walk)
- Stops along the way, such as picking up coffee or dropping off a friend
- Driving to a Park and Ride

* indicates Required - at least one mode of transportation to campus must be specified

1st part of your journey home from campus yesterday
Mode of Transportation *
Duration *

2nd part of your journey home from campus yesterday

Mode of Transportation
Duration

3rd part of your journey home from campus yesterday
Mode of Transportation
Duration

4th part of your journey home from campus yesterday
Mode of Transportation
Time or Distance

5th part of your journey home from campus yesterday
Mode of Transportation
Duration

**Describe your travel <u>to</u> campus on the *day before yesterday*.** If you did not come to campus on the day before yesterday, use the second to last day you did come to campus.

For each part of your journey to campus, include:
mode of transportation
the time it took or the distance traveled (not including waiting times)

A part of your journey to campus begins/ends whenever you have stopped *for a specific purpose*.

An example would be:
For the 1st part of your journey to campus, you would select "Car as driver" and then "5 miles" for the drive from home to the Park and Ride. Then for the bus ride to campus, you would select "Local Bus" and "15 minutes" as the 2nd part of your journey. After getting to campus if you walked to get coffee, you would select "Walk" and "5 minutes" for the 3rd part of your journey. Finally, you would select "Walk" and "10 minutes" for the 4th part of your journey to campus.

Be sure to include the following events in your journey:
- Change in travel mode (car-bus or bike-bus-bike or walk-bus-walk)
- Stops along the way, such as picking up coffee or dropping off a friend
- Driving to a Park and Ride

* indicates Required - at least one mode of transportation to campus must be specified

1st part of your journey to campus on the day before yesterday
Mode of Transportation *
Duration *

2nd part of your journey to campus on the day before yesterday

Mode of Transportation
Duration

3rd part of your journey to campus on the day before yesterday
Mode of Transportation
Duration

4th part of your journey to campus on the day before yesterday
Mode of Transportation
Duration

5th part of your journey to campus on the day before yesterday
Mode of Transportation
Duration

**Describe your travel home <u>from</u> campus on the *day before yesterday*.** If you did not come to campus on the day before yesterday, use the second to last day you did come to campus (i.e. the same day as the last question).

For each part of your journey to campus, include:
mode of transportation
the time it took or the distance traveled (not including waiting times)

A part of your journey to campus begins/ends whenever you have stopped *for a specific purpose*.

An example would be:
You walk to the bus stop to leave campus, so you select "Walk" for "15 minutes". Then, since you took the bus for the 2nd part of your journey home, you select "Local Bus" and "15 minutes". You get to the park and ride and used the "Car as driver" for the "3 miles" to drive to the grocery store. Finally, the 4th part of your journey home was by "Car as driver" for the remaining "2 miles" home.

Be sure to include the following events in your journey:
- Change in travel mode (car-bus or bike-bus-bike or walk-bus-walk)
- Stops along the way, such as picking up coffee or dropping off a friend
- Driving to a Park and Ride

* indicates Required - at least one mode of transportation to campus must be specified

1st part of your journey home from campus on the day before yesterday
Mode of Transportation *
Duration *

2nd part of your journey home from campus on the day before yesterday

Mode of Transportation
Duration

3rd part of your journey home from campus on the day before yesterday
Mode of Transportation
Duration

4th part of your journey home from campus on the day before yesterday
Mode of Transportation
Time or Distance

5th part of your journey home from campus on the day before yesterday
Mode of Transportation
Duration

Before coming to UNC, what were your main modes of transportation? Select all that apply.

- Walk
- Bicycle
- Train/Light Rail
- Bus
- Carpool / share car ride with others
- Drove alone
- Other (e.g. motorcycle, scooter)

Have you ever used public transit as your main mode of transportation to work or college for an extended length of time (longer than 2 weeks)?

- Yes
- No

Housing Information
The next questions will ask you about where you live during the semester. This may not be your permanent home, but the location where you sleep at night while you are studying at UNC.

This is the last part of the survey. You're almost done!

What type of housing do you live in currently?

- Detached House
- Duplex or Triplex

- Townhouse, Apartment or Condominium
- On-campus housing
- Other housing

Did you move to your residence after March of 2008?

- Yes
- No

Which types of housing were you hoping to live in when you were looking for housing? Select all that apply.

- Detached House
- Duplex or Triplex
- Townhouse, Apartment or Condominium
- On-campus housing
- Other housing

Did you use the map in the Smart Moves Apartment Finder, which shows bus routes and many apartments around Chapel Hill and Carrboro to find housing?


- Yes
- No

Have you ever used the map in the Smart Moves Apartment Finder, which shows bus routes and many apartments around Chapel Hill and Carrboro?


- Yes
- No

What factors are important to you as you are choosing a place to live? Select all that apply.

- Live with friends
- Size of rooms
- Close to transit
- Lively/quiet neighborhood
- Close to campus/work
- Safety
- Other:

What is the best way to communicate with you about walking, biking, riding the bus, and carpooling rather than driving alone?

- RedefineTravel.org
- UNC web site - CAP alternatives Program
- Daily TarHeel
- Posters
- Orientation
- Table set up in the Pit
- Facebook
- Other:

Survey Powered By Qualtrics

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